Lake James
Croxton Ditch Watershed
Feasibility Study

William W. Hill and Associates

I. PERSPECTIVE

Steuben County, a resort area of northeastern Indiana, contains approximately 100 lakes varying in size from a few acres to over 1000 acres. The lakes and associated activities have a significant economic impact on the region. County population in the winter months is between 20 and 30 thousand; expanding to an estimated 200,000 during the summer. Steuben County is reportedly one of the fastest growing counties in the State of Indiana.

Most of the county watershed drains to the West through Pigeon Creek and Fawn River to the Pigeon River and eventually to the St. Joseph River and Lake Michigan. The northeast corner of the county drains to the south to the Maumee Basin and Lake Erie.

The major lakes in the area are virtually saturated with residential development, reflecting an expansion in seasonal and full-time lake population that has taken place over the past thirty years. Industrial expansion has been actively and effectively pursued in recent years. These expansions together with the natural follow-on commercial development are beginning to stretch the county's infrastructure. During the growth of the region, however, the effect on the lakes and streams was often disregarded in the planning and approval processes with respect to expansion and development. The two largest county lakes, James and Crooked, are two examples where unnecessary harmful effects have been allowed to continue and justify the need for study and corrective action.

II. OBJECTIVES

Lake James is the largest body of water in the county, comprising approximately 1050 acres, and is one of several lakes in a chain beginning near the town of Fremont. The quality of the lake is primarily affected by three factors:

1 - inflow through the Marsh, Otter and Snow Lake chain which is influenced by a variety of land uses along the course,

2 - lake shoreline development including residential and Pokagon State Park, and

3 - inflow through drainage ditches serving the surrounding watershed.

The major inflow stream to Lake James is the John Croxton drain, shown in Figure I. The Croxton ditch serves a watershed of approximately 1100 acres. Past observations, water sampling, and measurements have indicated severe nutrient and sediment loads in the entering stream into Lake James. Figures II and III, taken in June of 1988, indicate the severity of the sediment problem at the mouth of the Croxton ditch as it enters Lake James.

The nutrient levels are the result of several land uses, while the sediment problem is largely the result of improper management of the topsoil and control of flow rates. A typical source of this problem is depicted in June of 1988 in Figures IV through VII which indicate the condition of the ditch and its banks along a portion of the ditch.

The objectives of the study are the verification of the magnitude of the problem, evaluation of the watershed land use, identification of the sources of the problem, and a determination of the feasibility of providing corrective measures.

III. Sampling and Survey Methods

The watershed land use was determined from both the Steuben County Soil Survey and field observations. The soils identified as highly erodible were color coded on the soil survey maps and the acreage determine by counting dots on an acreage scale for each land use.

Nutrient and sediment samples were taken during the summer of 1988 on dates given in Table II by grab samples. The sample was split and analyzed for phosphorus by persulfate digestion followed by the ammonium molybdate colorimetric method given in Standard Methods. Sediment amounts were determined by filtration through a 47 micron millipore membrane and weighed.

Storm hydrographs at two stations were determined from flow measurements using a temporary wooden weir and, in one instance, a collection device. Measured data was extropolated backward in time to the storm onset in order to obtain an estimate of the total flow quantity.

IV. WATERSHED LAND USE

The Croxton drain watershed and ditch course are shown in Figure I. The approximate 1100 acres served by the Croxton system is comprised of all of the possible land uses in significant amounts. The distribution is as follows:

Use		Area (acres)	Percent
Residential		120	11
Recreational (golf course)		160	15
Industrial		165	16
Commercial		175	16
Agricultural:	a) cropland	300	42
	b) woods and wetlands	45	
		1,065	

In addition, there are approximately 30 acres of low-lying marshy ground directly adjacent to the ditch. Figures VIII, IX and X depict the distribution and location of the various land uses throughout the watershed.

The above acreages represent the situation in early 1989. The region is in a rapid growth period, and indications are that commercial development will expand greatly in the strip along State Road 127 in the eastern portion of the watershed. The highway is currently being widened to four lanes north to County Road 200N. Much of the undeveloped ground along the strip is being sold and is currently zoned industrial or business. It is expected that as much as perhaps two-thirds of the watershed along 127 will be developed within the very near future.

V. WATERSHED CHARACTERISTICS

At the present time, in the upper half of the reach of the ditch, the land use pattern together with relatively high elevations and the relatively low normal water table result in high flow rates only during periods of significant rainfall.

In the lower half, conditions are somewhat different. A significant portion of the land is at lower elevations. The higher water table together with the significant watering occurring in the residential and golf course acreages, produces a small but continuous flow.

As indicated by nutrient concentrations and rainfall levels in Table II, there is elevated phosphorus concentrations at most inflow rates. Sediment appears to be a problem only during the high storm rates.

Rainfall The Angola rainfall records for a period of thirteen months are presented in Appendix A. The middle five months of 1988 were unusually dry, and the ditch flows correspondingly low. The weather station is located approximately two miles SE of the beginning of the ditch.

Soils Soil type information from the 1981 county survey is presented in Figure XI. The major direct impact of soil type on the situation under study is the susceptibility to erosion under the influence by wind and water. Some soil types are more prone to erosion because of their physical characteristics, steepness and length of slope, and direct contact with wind and water. The presence of residue and living vegetation can greatly reduce erosion on these potentially erosive soils.

Identified in Figure XI are the soils classified by a average to high value of erosion factor K and also in the wind erodible groups 1, 2 or 3. These soils can be classified as highly erodible, and comprise approximately 70% of the watershed area. Of the 445 agricultural acres, 263 are highly erodible soils (HEL). Also, 300 acres are currently being cropped, while 23 acres are in CRP.

VI. QUANTITATIVE ASSESSMENT

For the purposes of both a convenient and meaningful measurement scheme, the ditch course was divided into four natural segments:

1 - the short underground upstream portion serving primarily the commercial plaza area at the south end of the watershed.

Ditch length (underground)	1200 ft.	(8%)
Watershed area	55a	(5%)

The surface of this area is almost 100% impervious. The pipe enters the beginning of the open ditch at station I. See Figure I.

2 - the next short portion to the culvert under SR 127

Ditch length	1000 ft.	(7%)
Watershed area	95a	(9%)

A significant portion of the undeveloped and/or agricultural ground (UA) is served by this portion of the ditch; however, commercial expansion is expected along this portion of the highway in the near future.

3 - the central portion serving the SW quadrant of the intersection of CR 200 N and SR 127. The dominant influence in this region is the 162 acre industrial park. The measurement station, III, is the culvert under 200 N.

Ditch length	4300 ft.	29%
Watershed area	230 a^+	21%

4 - the downstream portion serving the golf course and the major residential areas within the drainage basin. Much of the I 69 run-off is contained within this reach. Again, significant acreage of undeveloped ground is included. The major measurement station, IV, was located at the culvert under CR 275 N as the ditch enters Lake James at LaGoona Park.

Ditch length	8400 ft.	56%
Watershed area	720 a^+	65%

For the purposes of this study, interest was focused on three characteristics of the ditch flow;

3. Improve ditch stability with improved bottom design, side slope vegetation, and control of surface water entry into the ditch all will assist in the solution.

4. The increased use of Best Management Practices within the agricultural portion of the watershed to control sheet, rill, and gully erosion.

EXECUTIVE SUMMARY

The quality of the water of Lake James is influenced, in part, by the inflow from the John Croxton Ditch. The ditch serves approximately 1100 acres, composed of five distinct land use areas:

1 - the North edge of Angola; largely commercially developed and expanding
2 - an expanding industrial park
3 - a golf course
4 - an expanding rural residential area
5 - agricultural and undeveloped land

Steuben County and Angola are in a significant growth mode, and the primary direction of movement and development impacts the Croxton watershed.

The study verified two problems associated with the water quality. The nutrient level in the ditch flow has increased eight-to ten-fold over the past ten years. The quality of the water in the lower basin has deteriorated over the same period.

Excessive sedimentation, a long-standing problem for property owners near the mouth of the ditch, is increasing in severity. The sediment load is the result of a number of conditions:

1 - presence of highly erodible soils
2 - lack of adequate vegetative cover in some of the undeveloped areas
3 - significant commercial and industrial development activity in sections of the watershed
4 - the absence of appropriate soil management techniques

Recommendations.

Correction of the problems is feasible, and centers on the control of nutrients and sediments within the watershed.

1. Three distinct wetland areas exist adjacent to the ditch which are not currently being utilized to filter nutrients and sediments. They have been bypassed during recent ditch construction. These areas could be effectively used through redesign of the ditch path.

2. The installation of erosion and sediment control practices during additional development within the watershed. The enactment of an erosion control ordinance by both the City of Angola and Steuben County would greatly enhance this process.

TABLES AND ILLUSTRATIONS

TABLE OF CONTENTS

flow rates
suspended solids
total phosphorus

A. Flow Rates

The use of computer models, particularly TR 55 and TR 2Ø, was considered for flow rate comparison and model verification. Due to the unique characteristics of the watershed and, to some extent, the drought conditions of 1988, it was felt that the effort would be unproductive. Much of the watershed is extremely chopped up with respect to terrain, soil type, slopes, etc., a large number of laterals and small interceptor tiles are utilized in portions of the watershed, and the golf course utilizes a significant number of small fringe ponds and ditches.

Due to the drought conditions, measured flow rates in 1988 will, for the most part, represent minimum conditions.

Typical measured flow rate data is illustrated in Figures XII and XIII, corresponding to the storm of August 5, 1988. The measurements at Stations I and III were made by means of an improvised weir and container where practical. In order to obtain an estimate of the integrated total flow, an extrapolation of the hydrograph is made to zero time. In spite of the inherent uncertainties and inaccuracies, the result should be a reasonable estimate of the total flow information that will assist in evaluating potential storage and detention areas.

The flow at Station I is largely due to the run-off from the hard surface and roofed commercial area and is little affected by soil conditions. Station III is approximately 53ØØ feet downstream of Station I, and the intervening distance is currently relatively undeveloped. Under the drought conditions existing, a greater percentage of the rainfall was absorbed and stored in the ground. The peak flow rate and the total flow at Station III was, therefore, lower than would be expected under normal weather conditions.

Figure XIV depicts the results of similar measurements at Station III during a storm event in early September.

The Croxton ditch empties into a U-shaped channel at LaGoona Park which acts as a settling pond. It is interesting to compare the storm event total flows of approximately Ø.8 acre feet to the total volume of water in the channels of approximately 7 acre feet.

B. NUTRIENT AND SEDIMENT LOAD

1 - Ditch Results of the sampling are presented in Tables I and II. Figure XV compares the nutrient results with data from the monitoring programs of the Steuben County Lakes Council and the Steuben County Health Department in previous years. The manifold increase in the nutrient load over the years is evident. In addition, the dependence of both nutrient and sediment concentration on rainfall is clear. On May 23, 1988 the recorded rainfall was 1.98 inches, the largest storm during the study period. The data also lends credence to the notion that much of the nutrients in the flows are attached to sediment. Although certainly not linear, the trend is clear with the rainfalls of smaller magnitude, as indicated in Tables I and II.

2 - Lake James - Lower Basin The Indiana State Board of Health developed the Lake Eutrophication Index which consists of eleven parameters. Two of these are the secchi disk and total phosphorus readings. In the mid 1970's the secchi disk reading was 12 feet and the total phosphorus ranged from 0.02 to 0.03 mg/l for Lake James. The 1988 readings of 9 feet for the secchi disk and 0.035 mg/l for total phosphorus indicate a decline in water quality. Although these changes have not created a serious water quality problem yet, the trend cannot be permitted to continue.

During the 1970's the Steuben County Health Department monitored several inflow streams on the larger lakes in Steuben County including the Croxton Ditch. During each of the years the following number of samples were taken, 1973 (7 samples), 1974 (17 samples), 1975 (9 samples), 1976 (9 samples), and 1977 (7 samples) were taken each year at 275N, the mouth of the Croxton Ditch. The averages of this phosphate data is given in Figure XV. In 1987 the Steuben County Lakes Council funded a sampling program at Tri-State University. Five samples were taken to determine the yearly average for 1987. In 1988, eight phosphate samples were taken.

According to the Skinner Lake Study as much as 90% of the phosphorus entering a lake in northeastern Indiana is attached to sediments. Also the Environmental Impact Statement done for the Steuben Lakes Regional Waste District in 1979 indicates approximately 10% of the phosphorus coming from septic system leachate, eventually reaches the lake. Most of these septic systems have been corrected by the construction of cluster systems by the Steuben Lakes Regional Waste District during the past ten years. During the summer of 1987 and 1988, Pokagon State Park was in noncompliance of the phosphorus limits on their NPDES permit. Due to improved maintenance and management they have been in compliance for all of 1989. Most of the current phosphate inflow is coming from other sources. The sediments and associated nutrients entering Lake James through the Croxton ditch is the last major contributor of phosphorus that needs to be corrected.

VII. CONCLUSIONS

In terms of the four program objectives as stated in Section II.

A. Magnitude of Problem

The nutrient load in the John Croxton ditch has increased approximately ten times during the past ten years.

Although reference sediment data does not exist prior to 1988, it has been apparent that alterations to the character of the Croxton ditch have magnified the problem. Observed levels in the 1988 measurements indicate a situation that should be addressed.

B. Watershed Land Use

Although increased commercialization will remove some of the undeveloped and agricultural land as nutrient source, the new uses pose a potential problem source for salts, oils, etc.

In addition, the paving of these areas along with the associated building construction will generate a more rapid hydraulic load and increased potential for harmful erosion. This, combined with the cumulative effects of wetland loss, has amplified the effects of activities within the watershed on Lake James.

C. Problem Sources

Nutrients All areas of the watershed contribute to the nutrient load. The major sources are the agricultural and undeveloped areas along with the residential, golf course combination.

Sediment Three sources exist; 1) highly erodible soils in the agricultural, recreational and undeveloped areas, 2) poor soil management during construction activities and 3) poor ditch bank management and maintenance.

The sediment load has been enhanced by the cleaning and lengthening of the ditch along with increased construction activity in the industrial park during the 1980's. In addition, reconstruction of the ditch in 1987 caused channelization through some of the wetland areas, minimizing their impact on the flow quality.

Consideration of all factors indicate that the situation will continue at least at the current levels.

D. Feasibility of Correction

Potential correction of the existing problems takes two forms:

1 - hydraulic and biological "treatment" of the flow, including the effective utilization of wetlands, to reduce the sediment and nutrient levels prior to discharge to Lake James.

Land exists within the watershed that can be used to effectively accomplish this goal; land that is not currently of a productive nature.

2 - land and land use management.

Agriculture. Several types of reduced tillage, filer strips, grass waterways, and terraces are possible site specific solutions to reducing erosion on agricultural land. In addition, proper nutrient management of both commercial fertilizers and animal wastes are critical to reducing lake input. The Steuben County Soil and Water Conservation District would be valuable in selecting the most appropriate BMP's for each situation.

Non-agriculture. Storm water retention, erosion control during construction, proper design of ditch inflow structures, and stabilization of existing ditch conditions are all factors that need to be addressed. The adoption of an Erosion Control Ordinance and education of all sectors involved could help correct a growing problem. Again, the Steuben County Soil and Water Conservation District could be an ideal lead agency.

VIII. RECOMMENDATIONS

A. Proceed with the design phase to incorporate retention and detention areas within the watershed to provide for both sediment deposition and nutrient removal. The existing wetland and marsh areas as indicated in Figure X can effectively be used, along with the possibility of creating new "treatment" areas.

B. Provide an educational service to city and county agencies with respect to the impact of development on the downstream problems. Such educational services could be effectively provided in cooperation between the Steuben County Soil and Water Conservation District and the Steuben County Lakes Council.

C. Implement an Erosion Control Ordinance in the planning ordinances of Steuben County and the City of Angola.

D. Encourage the agricultural sector of the watershed to apply the following Best Management Practices (BMP's) where needed:

1 - Nutrient management of both commercial fertilizers and animal wastes.

2 - Conservation tillage methods.

3 - Filter strips along the Coxton ditch in both the agricultural and commercial areas.

4 - Other site specific BMP's as recommended by the SCSWCD.

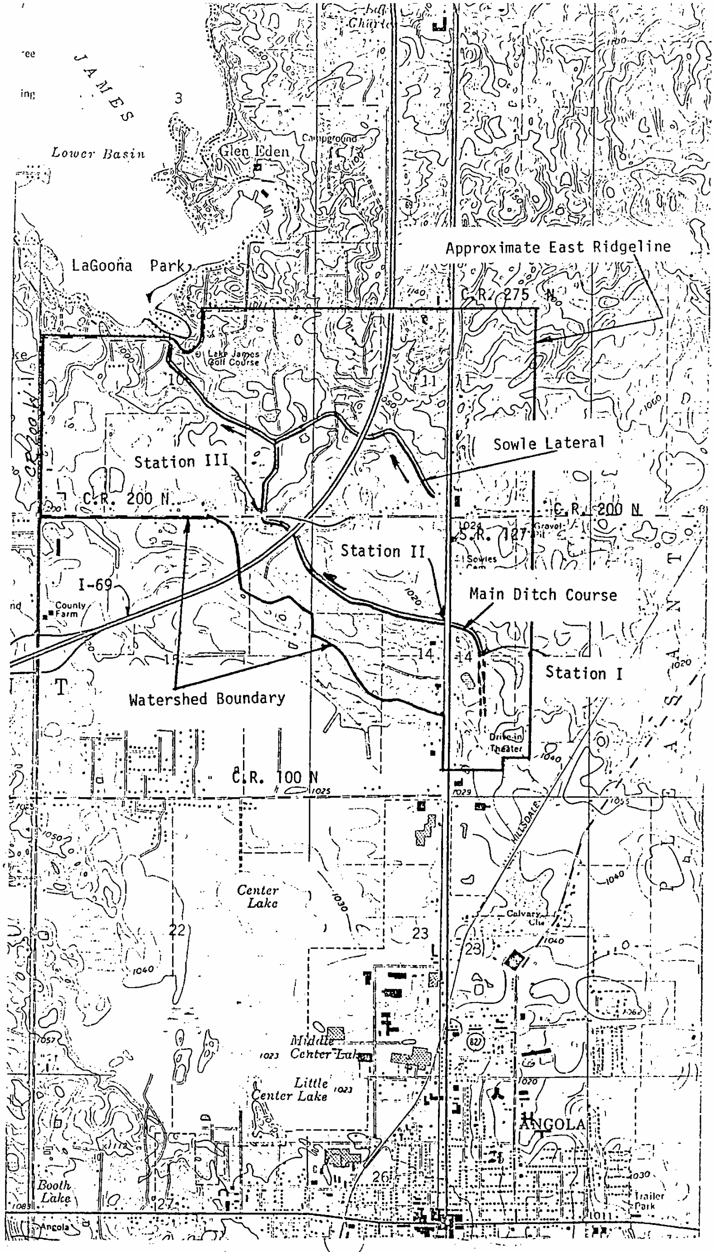


Figure I. The John Croxton Ditch

Scale: 1/24,000

— Ditch Course

— Watershed Boundary

Figure II. Discharge from LaGoona Park Channels at mouth of Croxton Ditch - normal condition

Figure III. Discharge from LaGoona Park Channels at mouth of Croxton ditch - storm condition

Figure IV. John Croxton Ditch - Typical Bank Conditions within Industrial Park

Figure V. John Croxton Ditch - Typical Bed Conditions within Industrial Park

Figure VI. John Croxton Ditch. Typical Bank conditions at Bend. Industrial Park

Figure VII. John Croxton Ditch. Typical Site Conditions. No seeding or detention areas long after plant opening.

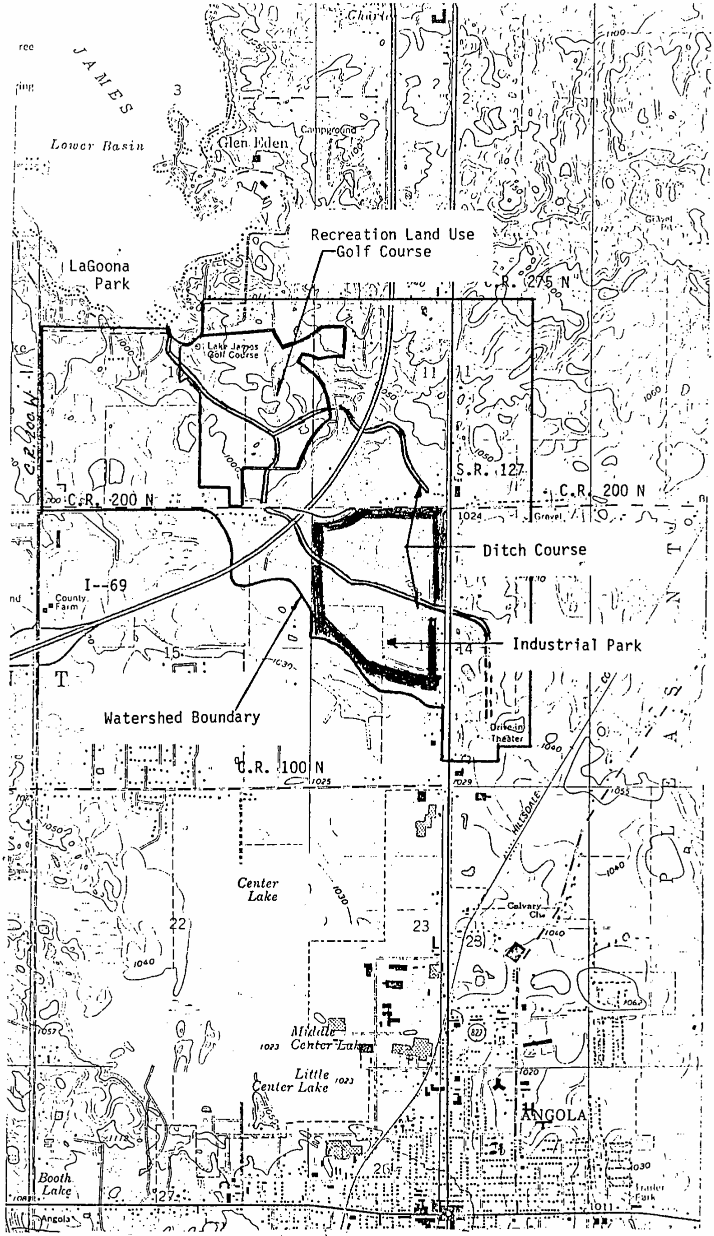


Figure VIII. The John Croxton Ditch; Land Use

Ditch Course — Watershed Boundary
Recreation — Industrial Park

Scale: 1/24000

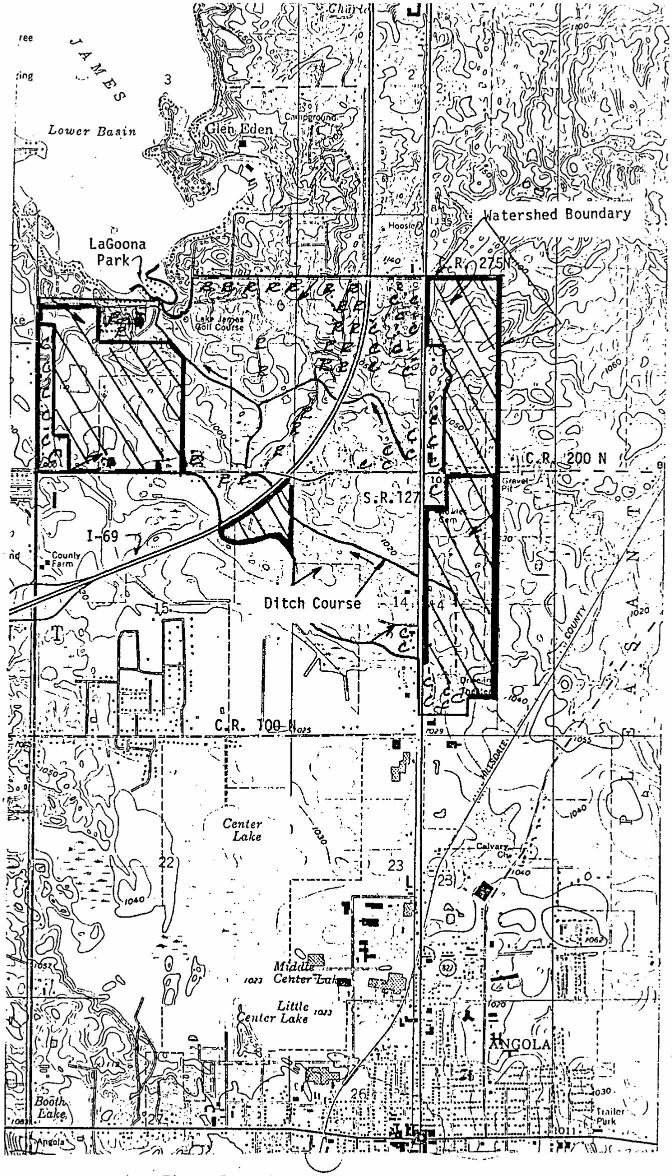


Figure IX. The John Croxton Ditch; Land Use

— Ditch Course — Watershed Boundary *R* Residential *C* Commercial

▨ Agriculture and Undeveloped

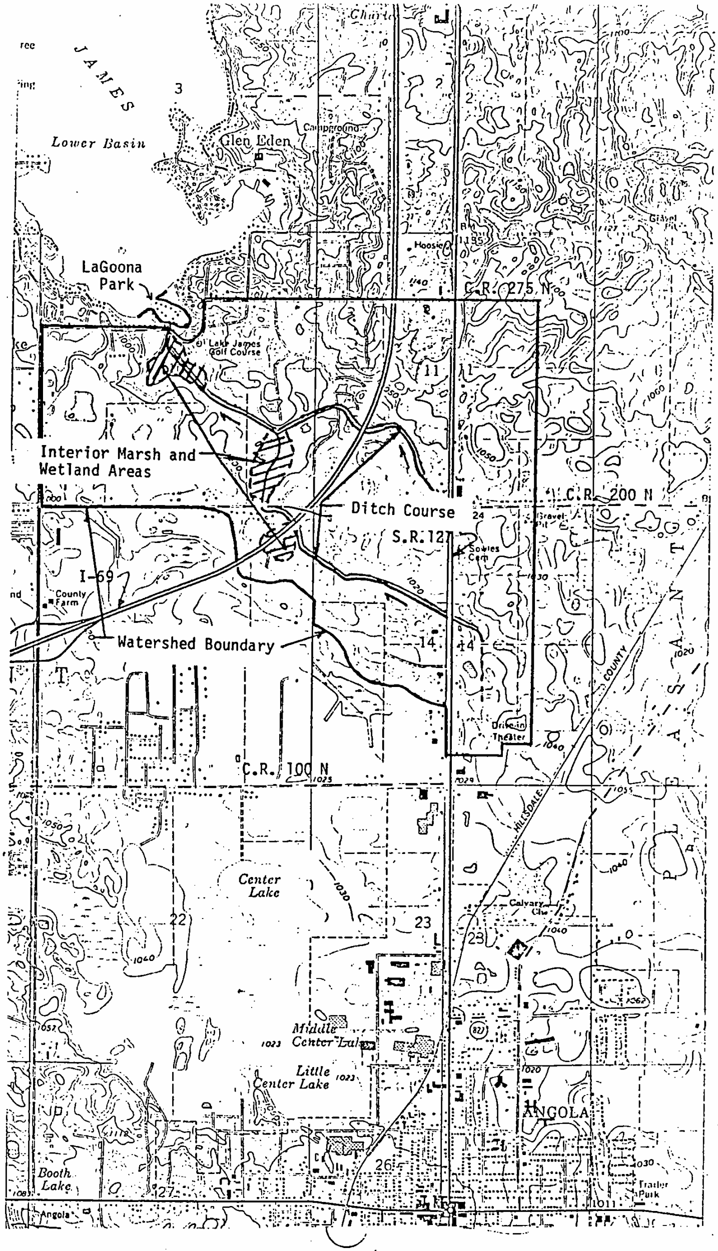


Figure X. The John Croxton Ditch; Land Use

═ Ditch Course — Watershed Boundary Marsh/Wetlands

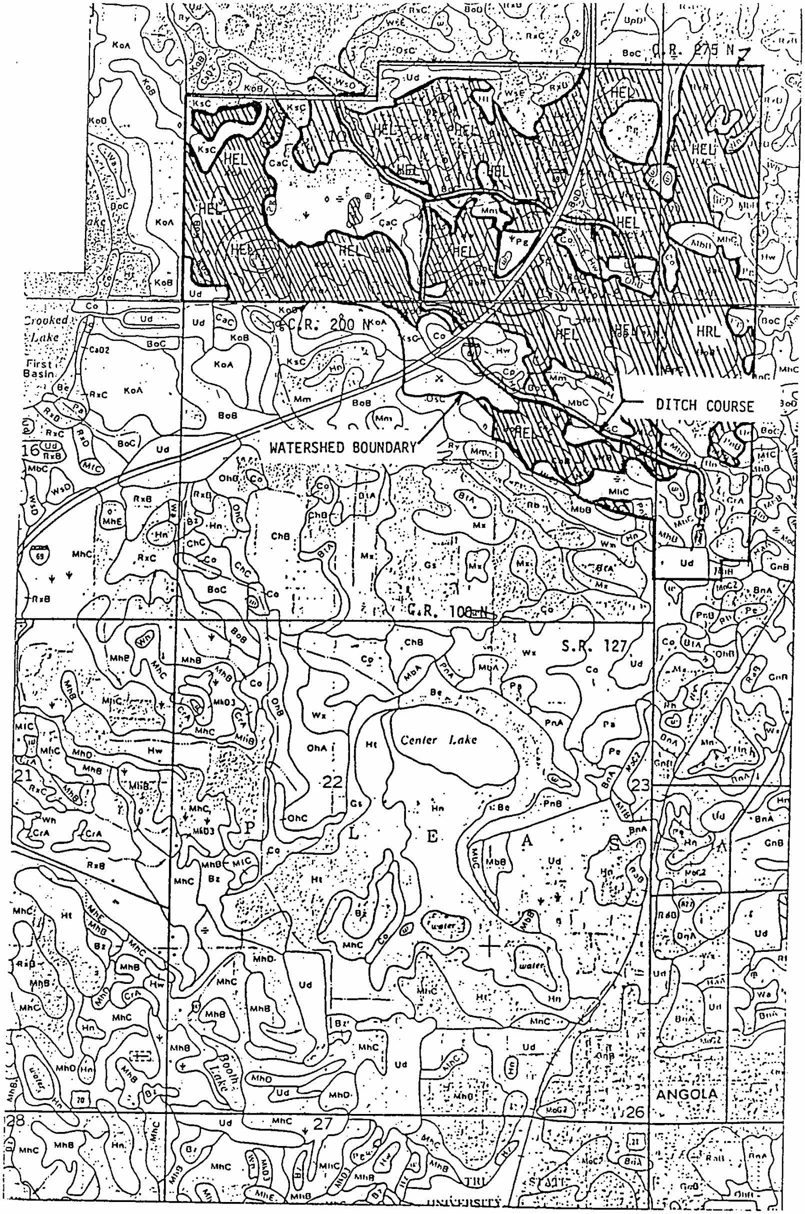


Figure XI. <u>The John Croxton Ditch; Soil Identification</u>

— Ditch Course — Watershed Boundary Highly Erodible Soils HEL

Scale; 1/20000

Figure XII MEASURED STORM HYDROGRAPH

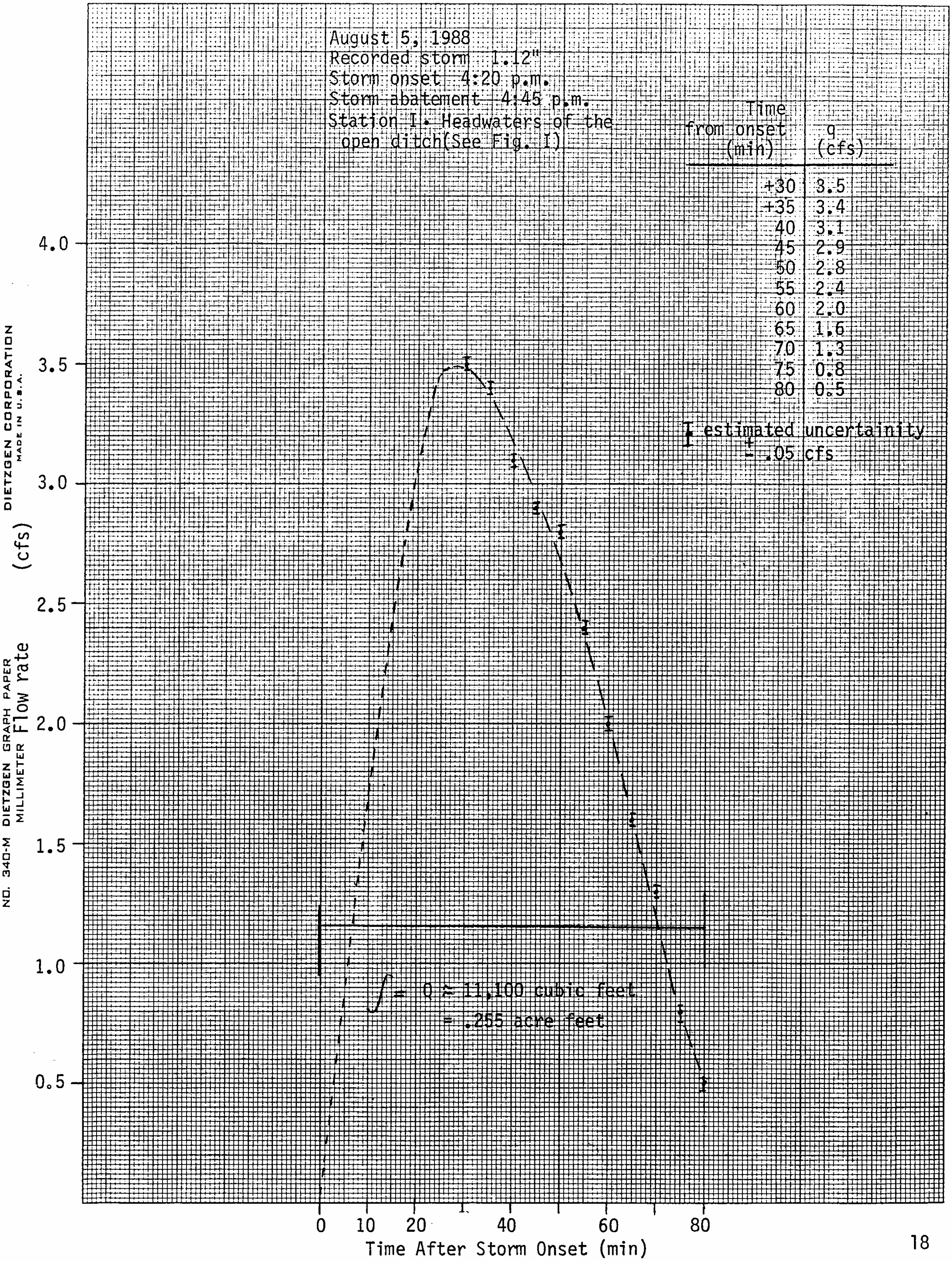
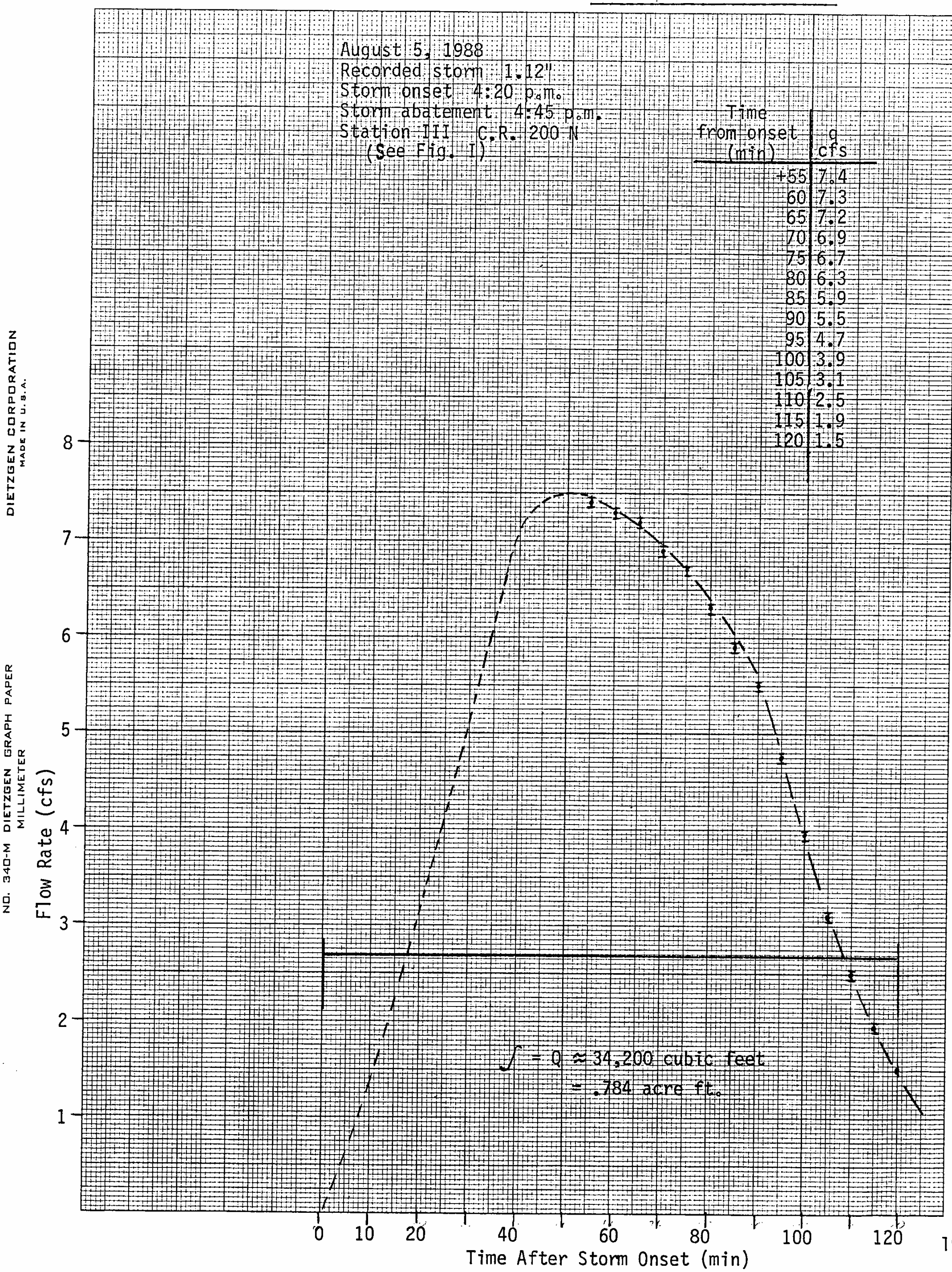
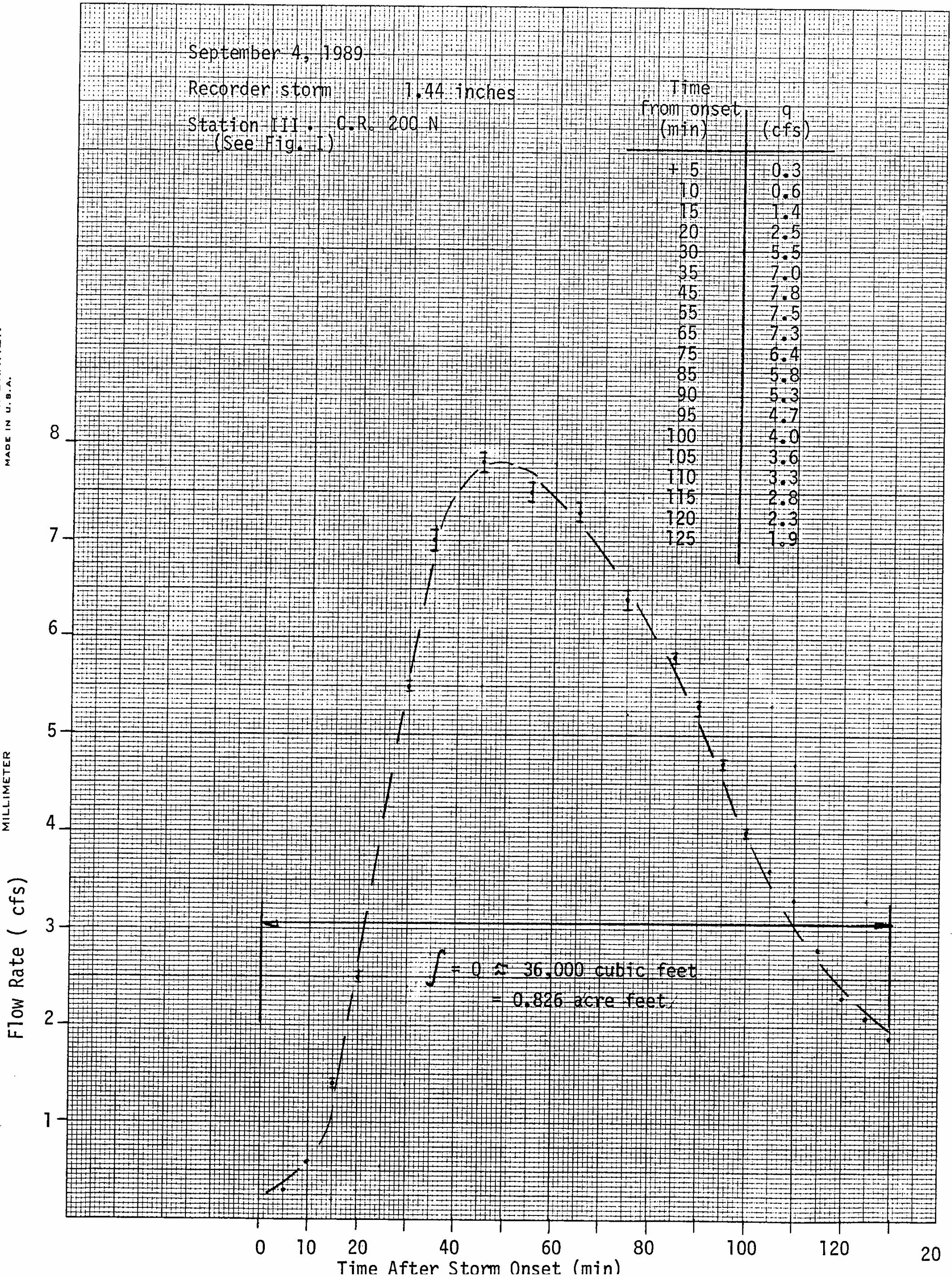


Figure XIII MEASURED STORM HYDROGRAPH



Time from onset (min)	q cfs
+55	7.4
60	7.3
65	7.2
70	6.9
75	6.7
80	6.3
85	5.9
90	5.5
95	4.7
100	3.9
105	3.1
110	2.5
115	1.9
120	1.5

Figure XIV MEASURED STORM HYDROGRAPH



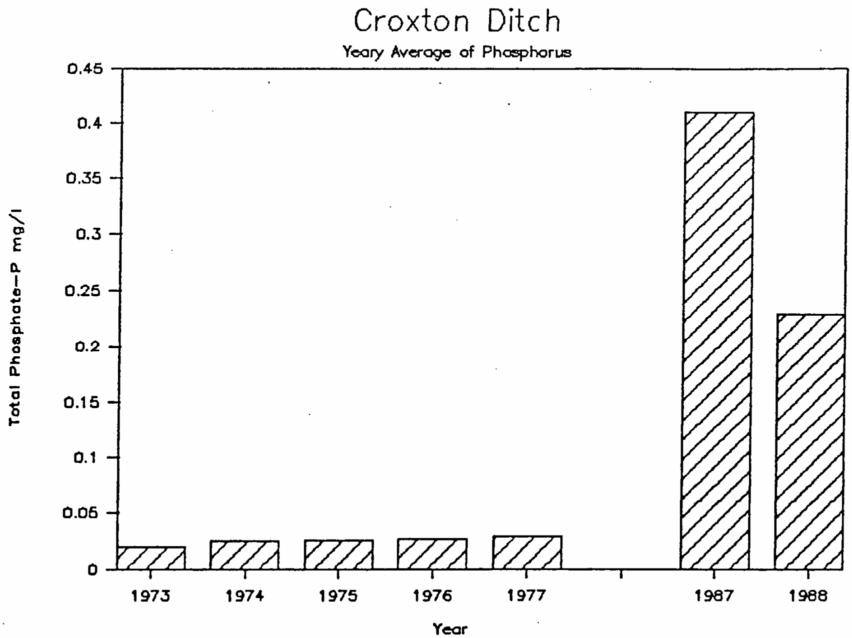


Figure XV. The John Croxton Ditch; Total Phosphate-P Content

Croxton Ditch			Total Phosphate -P mg/l					
1988	5/23	6/16	7/14	7/19	7/26	8/15	8/19	8/27
SR 127	0.50	0.20	0.50	0.02		0.34	0.17	
200 N	0.45	0.16	0.21	0.05		0.40	0.03	0.09
275 N	0.50	0.095	0.06	0.09	0.70	0.27	0.06	0.10
Sowles lateral at I 69								0.63
Pond at 14 green								0.09
West edge of #1 fairway								0.14
Confluence with Sowle lateral								0.04
Rainfall (inches)	1.98		0.34	0.10	0.08	0.46	0.18	0.63

Table I. John Croxton Ditch - Total Phosphate - P Measurements Along Ditch Course

Croxton Ditch		Suspended Sediments mg/100ml					
Date in 1988	5/23	6/16	7/14	7/19	8/5	8/19	8/27
SR 127	120.00	84.00			62.00		
200 N	145.00	95.00			96.00		78.00
275 N	158.00	90.00			84.00		60.00
Sowles lateral at I 69							25.00
Pond at # 14 green							65.00
West edge of #1 fairway							60.00
Confluence with Sowle lateral							55.00
Rainfall (inches)	1.98		0.34	0.10	1.12	0.18	0.63

Table II. John Croxton Ditch - Suspended Sediment Measurements Along Ditch Course

APPENDIX A

Table I. 1988-89 Rainfall Record, Angola, Indiana

JULY 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
July 10	5:30 AM - 7:00 AM	.02
July 10	7:00 AM - 11:30 AM 2:00 PM - 6:30 PM	.90
July 14	5:30 PM - 7:00 AM	.34
July 14	7:00 AM - 7:30 AM	.01
July 16	10:00 PM - 11:30 PM	.22
July 18	2:30 PM - 7:00 PM	.10
July 20	11:30 AM - 1:00 PM	.17
July 23	3:00 PM - 9:00 PM	.67
July 25	5:00 PM - 7:00 PM	.08
July 30	Times Unknown	.15
	TOTAL	2.66

Trace = less than .01 inch of precipitation

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AUGUST 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX 12-0200-03

DATE	TIMES		AMOUNT
Aug 5	4:00 PM - 6:00 PM		1.12
Aug 9			Trace
Aug 10	3:00 PM - 5:00 PM		.09
Aug 15	1:00 AM - 3:00 AM		.23
Aug 15	7:30 AM - 9:00 AM		.46
Aug 18	9:00 PM - 11:00 PM		.50
Aug 19	1:00 PM - 2:00 PM		.18
Aug 23	5:30 AM - 7:00 AM		.63
Aug 23	7:00 AM - 9:00 AM		.02
Aug 27	5:30 PM - 10:00 PM		.63
		TOTAL	3.86

Trace = less than .01 inch of precipitation

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SEPTEMBER 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Sept 1	6:00 PM - 12:00 MID	.97
Sept 3	7:00 AM - 12:00 MID	
Sept 4	12:00 MID - 7:00 AM	1.44
Sept 4	7:00 AM - 12:00 NOON	.40
Sept 5	Times Unknown	.07
Sept 12	Times Unknown	.11
Sept 18	3:00 PM - 5:00 PM	.64
Sept 19	8:00 AM - 12:00 MID	
Sept 20	12:00 MID - 6:30 AM	1.32
Sept 20		Trace
Sept 22	Times Unknown	.11
	TOTAL	5.06

Trace = less than .01 inch of precipitation

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OCTOBER 1988 PRECIPITATION
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Oct 2	3:00 AM - 7:00 AM	.54
Oct 2	7:00 AM - 12:00 MID	
Oct 3	12:00 MID - 3:00 AM	.22
Oct 5	Times Unknown	.07
Oct 9	6:00 AM - 7:00 AM	.05
Oct 9	7:00 AM - 9:30 AM	.16
Oct 10	Times Unknown	.07
Oct 11	Times Unknown	.04
Oct 12		Trace
Oct 15	Times Unknown	.32
Oct 16	3:00 PM - 12:00 MID	3.19
Oct 17	Times Unknown	.02
Oct 18		Trace
Oct 19	Times Unknown	.06
Oct 20	Times Unknown	.14
Oct 23	10:00 AM - 2:00 PM	.39
Oct 24	Times Unknown	.03
Oct 26		Trace
	TOTAL	5.30

Trace = less than .01 inch of precipitation

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NOVEMBER 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Nov 1		Trace
Nov 3		Trace
Nov 4	11:00 AM - 12:00 MID	.67
Nov 5	7:00 AM - 12:00 MID	
Nov 6	12:00 MID - 7:00 AM	.21
Nov 6	7:00 AM - 11:30 AM	.30
Nov 9		Trace
Nov 10	5:00 PM - 12:00 MID	
Nov 11	12:00 MID - 3:00 AM	.10
Nov 13	12:00 MID - 4:00 AM	.33
Nov 15	6:00 PM - 12:00 MID	
Nov 16	12:00 MID - 7:00 AM	.68
Nov 16	7:00 AM - 12:00 NOON	.82
Nov 20	4:00 AM - 7:00 AM	.28
Nov 20	7:00 AM - 2:00 PM	.68
Nov 26	12:00 NOON- 12:00 MID	
Nov 27	12:00 MID - 7:00 AM	.56
Nov 27		Trace
Nov 29	Times Unknown	.03
	TOTAL	4.66

Trace = less than .01 inch of precipitation

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DECEMBER 1988 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Dec. 1	Time Unknown	.05
Dec. 10		T
Dec. 11	Time Unknown	.03
Dec. 13	2:00 AM - 3:00 AM	.07
Dec. 14		T
Dec. 15		T
Dec. 16		T
Dec. 17	Time Unknown	.05
Dec. 18	3:00 AM - Midnight	.07
Dec. 19	Midnight - 4:00 AM	.02
Dec. 20		T
Dec. 22	9:00 AM - 1:00 PM	.92
Dec. 25	Time Unknown	.15
Dec. 26 Dec. 27	7:00 AM - Midnight Midnight - 7:00 AM	.68
Dec. 28	7:00 AM - 9:00 AM	.48
	TOTAL	2.52

Trace = less than .01 inch of precipitation

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JANUARY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Jan. 2		T
Jan. 3	9:00 AM - 12:00 N	.10
Jan. 5 Jan. 6	9:00 PM - Midnight Midnight - 7:00 AM	.55
Jan. 7	7:30 PM - 11:00 PM	.48
Jan. 11	Time Unknown	.07
Jan. 14	3:00 PM - 6:30 PM	.18
Jan. 20	Time Unknown	.04
Jan. 25 Jan. 26	8:00 PM - Midnight Midnight - 3:00 AM	.16
Jan. 29	1:30 AM - 3:00 AM	.14
Jan. 30	Time Unknown	.06
	TOTAL	1.68

Trace = less than .01 inch of precipitation

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COOPERATIVE WEATHER STATION
ANGOLA, INDIANA
STATION INDEX 12-0200-03

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FEBRUARY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Feb. 2	Time Unknown	.03
Feb. 3		T
Feb. 5	Time Unknown	.12
Feb. 6	Time Unknown	.24
Feb. 12		T
Feb. 13	10:30 AM - 12:30 PM	.19
Feb. 16	Time Unknown	.05
Feb. 19	Time Unknown	.02
Feb. 20	Time Unknown	.02
Feb. 21		T
Feb. 22		T
Feb. 23		T
Feb. 27		T
Feb. 28		T
	TOTAL	1.05

Trace = less than .01 inch of precipitation

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MARCH 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Mar. 3	Time Unknown	.02
Mar. 4	3:00 AM - 7:00 AM	.22
Mar. 5	Time Unknown	.03
Mar. 14	8:00 PM - 9:00 PM	.09
Mar. 15	Time Unknown	.02
Mar. 17 Mar. 18	6:00 PM - Midnight Midnight - 1:30 AM	.78
Mar. 19		T
Mar. 20	11:00 AM - 12:30 PM	.16
Mar. 27	12:00 N - 1:30 PM	.03
Mar. 28	9:00 PM - 10:30 PM	.17
Mar. 30	Time Unknown	.04
Mar. 31		T
	TOTAL	1.57

Trace = less than .01 inch of precipitation

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APRIL 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
Apr. 1		T
Apr. 2	9:00 AM - 8:00 PM	1.08
Apr. 3	Time Unknown	.43
Apr. 4	Time Unknown	.10
Apr. 7	Time Unknown	.07
Apr. 8		T
Apr. 9		T
Apr. 10		T
Apr. 11		T
Apr. 12		T
Apr. 13	Time Unknown	.15
Apr. 15	Time Unknown	.09
Apr. 18	Time Unknown	.26
Apr. 19	Time Unknown	.19
Apr. 25	5:30 AM - 8:00 AM	.41
Apr. 28	5:00 AM - 11:00 AM	.65
	TOTAL	3.43

Trace = less than .01 inch of precipitation

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MAY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
May 2	7:30 AM - 9:00 AM	.19
May 5	Time Unknown	.09
May 6		T
May 7	Time Unknown	.02
May 9	6:00 AM - 9:00 AM	.13
May 12 May 13	9:00 PM - Midnight Midnight - 3:00 AM	.44
May 14	Time Unknown	.04
May 16	Time Unknown	.03
May 19	5:00 AM - 6:00 PM	1.10
May 25	4:00 AM - 6:00 AM	.85
May 26	7:30 PM - 11:30 PM	.43
May 29		T
May 30	1:00 PM - 2:30 PM 8:30 PM - 11:30 PM	2.63
	TOTAL	5.95

Trace = less than .01 inch of precipitation

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JUNE 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
June 1	9:30 AM - 2:00 PM	1.29
June 3	11:00 AM - 5:00 PM	.61
June 11	10:00 AM - 6:00 PM	.47
June 14	Time Unknown	.07
June 15		T
June 16	Time Unknown	.04
June 17	3:00 PM - 4:00 PM	.12
June 19	3:00 PM - 5:00 PM	1.66
June 27	11:00 AM - 12:30 PM	.15
	TOTAL	4.41

Trace = less than .01 inch of precipitation

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JULY 1989 PRECIPITATION SUMMARY
ANGOLA, INDIANA

STATION INDEX: 12-0200-03

DATE	TIMES	AMOUNT
July 2	3:30 PM - 4:30 PM	.12
July 9	3:30 AM - 7:00 AM	.59
July 11	3:00 AM - 6:00 AM	1.75
July 13	11:00 AM - 12:30 PM	.08
July 19	5:00 AM - 8:00 AM	.19
July 20		T
July 21	4:30 AM - 9:30 AM	.30
July 25	9:30 PM - 11:30 PM	1.02
July 27	Time Unknown	.02
July 28	Time Unknown	.06
July 30	4:00 AM - 8:00 AM	.37
	TOTAL	4.50

Trace = less than .01 inch of precipitation

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